スピン軌道トルクを利用した局所領域における磁化ダイナミクスの共鳴励起に関するマイクロマグネティクスシミュレーション

Micromagnetic Study of Resonant Excitation of Magnetization Dynamics in Local Region Induced by the Spin-Orbit Torque

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Spin waves are being actively studied for their proposed applications in magnetic sensors, logic devices, and reservoir computing. For these applications, it is important to excite highly coherent spin waves. One of the methods to excite spin waves is to use the spin-orbit torque (SOT) acting at the interface between nonmagnetic metal and ferromagnetic metal multilayers. In this paper, we report on the micromagnetic study on the condition of the control of the coherency of spin waves by applying the spin-orbit torque in a local region of a ferromagnetic thin film. We find that a confinement effect of spin waves under an external magnetic field generates highly coherent spin waves.

The numerical simulations based on micromagnetics were performed using the object oriented micromagnetic framework (OOMMF) [1]. The simulation model is shown in Fig. 1(a). The film thickness was set to 10 nm using the physical properties of yttrium iron garnet (YIG). The SOT is applied to a 200 nm × 100 nm area in a 2 μm square region. The cell size is 5 nm in the x and y directions and 10 nm in the z direction, the external magnetic field (2 kOe) is applied in the −x direction in the plane, and the SOT is applied in the +x direction. When the current is above a threshold value, the SOT effectively excites the magnetization precession motion. On the other hand, when the current is too large, the magnetization direction reverses in a part of the applied region, and the coherence of the spin wave is significantly reduced. Figure 1(b) shows a result of numerical simulation under the condition of highly coherent spin wave formation. We find that the emission of highly coherent spin waves is related to the partial confinement of spin waves in the SOT applied region. In this presentation, the details of the mechanism will be discussed.

References [1] M. J. Donahue et al., “OOMMF user’s guide, version 1.0,”Interagency Report No. NISTIR 6376 (National Institute of Standards and Technology, Gaithersburg, MD, 1999).

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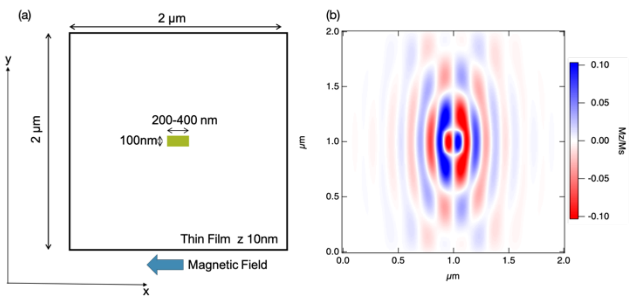

Fig. 1. (a) Simulation Model. (b) Numerical simulation result under the highly coherent spin waves. The blue and red colors represent the +z and −z components of the magnetization, respectively.